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U.R.S.I. SYMPOSIUM 1980 ON ELECTROMAGNETIC WAVES.(U)
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U.R.S.I. Symposium 1980 on Electromagnetic Waves
T.C. Cheston David K. Cheng*
22 October 1980

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UNITED STATES OF AMERICA

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ONRL C-6-80	2. GOVT ACCESSION NO. AD-A093 641	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) U.R.S.I. Symposium 1980 on Electromagnetic Waves.		5. TYPE OF REPORT & PERIOD COVERED Conference rept.
		6. PERFORMING ORG. REPORT NUMBER C-6-80
7. AUTHOR(s) T.C. Cheston, David K. Cheng (Syracuse University)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Naval Research, Branch Office London Box 39 FPO NY 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 22 October 1980
		13. NUMBER OF PAGES 6
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12 8		15. SECURITY CLASS. (of this report)
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE;DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

URSI
International Symposium
Electromagnetic Waves
Bioelectromagnetics
Scattering
Diffraction

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The 1980 International U.R.S.I. (Union Radio Scientifique Internationale) Symposium on Electromagnetic Waves was held in Munich. The report reviews the symposium and some of the papers.

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U.R.S.I. Symposium 1980 on Electromagnetic Waves

International U.R.S.I. (Union Radio Scientifique Internationale) symposia on electromagnetic waves have been held every three years and in many countries, since the first meeting in Montreal in 1953. The 1980 meeting was held in Munich, August 26-29, at the Technical University. Munich is a most hospitable town with much charm and it treated its visitors well.

During the opening ceremonies, Prof. R. Zapf, vice-president of the Technical University, welcomed the visitors and rather amusingly suggested in excellent English, that this symposium, like most international conferences nowadays, would be conducted in broken English. (Indeed, this was true, and some two weeks later the 10th European Microwave conference in Warsaw was also conducted in broken English.) Zapf could not resist the opportunity to insert a message to the city and state officials present at this opening, telling them that the universities had too many students and not enough money and were subject to too much bureaucracy.

One-hundred and seventy contributions from 25 countries had been accepted for the symposium. The chairman was Prof. G. Riefke. Unfortunately, several of the authors did not turn up, including some scheduled to give invited papers. The symposium was well attended, with about 200 people registering. Three parallel sessions were going most of the time.

L.B. Felsen of the Polytechnic Institute of New York discussed a hybrid-ray-mode field formulation in inhomogeneous media (Paper No. 111B). High-frequency fields radiated by sources in transversely inhomogeneous waveguides or ducts are usually analyzed in terms of a normal-mode expansion or by ray techniques. However, these techniques lead to computational difficulties for poorly convergent fields which involve an excessively large number of modes or rays, and corrections are required near the caustics and cusps of the ray system. Felsen suggested a hybrid formulation representation which utilizes an appropriately chosen mixture of modal fields and ray fields. The motivations are to achieve a fast convergence and therefore an ease of computation, to afford a better physical insight, and to avoid difficult transition regions where caustics and cusps accumulate. This hybrid representation has been applied to analyze high-frequency underwater sound propagation in ocean channels (Paper No. 121C by S.H. Cho and Felsen) and wave propagation in tropospheric ducts and along concave conducting surfaces.

In treating electromagnetic radiation and scattering problems for arbitrarily shaped conducting bodies using planar triangular-patch modeling, D.R. Wilton et al. of the University of Mississippi introduced a special basis function to represent the time-harmonic surface currents in their paper (No. 131B) "Electromagnetic Scattering by Surfaces of Arbitrary Shape." Planar triangular patches conform well to arbitrary geometrical surfaces and boundaries and they allow greater resolution of surface currents in specified regions by using a greater patch density. The method of moments is applied to scattering problems of both the electric-field and the magnetic-field integral-equation formulations. Illustrative examples were given, including one which determined the input admittance as a function of frequency for a wire antenna mounted at the center of a square plate driven at the base.

G.C. Herman of Delft University of Technology in a paper (No. 133B) entitled "Scattering of Transient Acoustic Waves by an Inhomogeneous Obstacle" described a volume-integral-equation approach to study the scattering of transient acoustic waves by arbitarily shaped, imhomogeneous, penetrable objects. Good agreement with calculated results derived from the fast-Fourier-transform inversion of classical frequency-domain solutions was obtained for the scattering of Gaussian-shaped pressure waves by a homogeneous sphere. The sphere was divided into 8 equal octants containing 20 tetrahedra each. Scattering data from both a homogeneous cube and an inhomogeneous cube were presented. The solutions were stable and the approach was claimed to be a unique one.

The electromagnetic diffraction fields of complex objects are usually difficult and tedious to determine. In a paper (No. 135B) "Experimental Study of Diffraction Fields Using Holographic Techniques ," M.G. Kirchner of Ruhr-Universität Bochum described a holographic method for displaying diffraction fields and interference patterns experimentally. Holographic real-time interferometry and double-exposure interferometry were used. Typical diffraction fields behind a half-plane and interference patterns behind a sectional slot were shown. It was pointed out that double-or multiple-exposure techniques could also be used to synthesize diffraction fields by superposing several diffraction waves.

In analyzing wave propagation and reflection in anisotropic media it is customary to use one or more coordinate systems. The coordinate method tends to render the solution difficult and to make the final result cumbersome. In a paper entitled "A Coordinate-Free Approach to Wave Reflection from an Anisotropic Medium (Paper No. 142C) H.C. Chen of Ohio University proposed to manipulate vectors, dyadics, and their invariants directly, thereby eliminating the use of coordinate systems. A coordinate-free dispersion equation and a Booker quartic equation were obtained. The transmission and reflection coefficients at an isotropic-anisotropic interface were determined. This approach may well lead to useful general results and conclusions without being encumbered by particular coordinate systems.

N.G. Alexpoulos et al. of the University of California at Los Angeles analyzed the "Radiation Properties of Microstrip Yagi-Uda Arrays" (Paper No. 211A) by reducing Pocklington's integral equation to a matrix equation using Galerkin's method. The determination of the currents in the printed array elements involved both space-wave and surface-wave interactions. However, the attention of the reported work was primarily directed toward the evaluation of the dyadic Green's functions and the analysis technique has not yet been extended to solve synthesis or optimization problems.

The phase center of an antenna can be defined as the point from which the radiation seems to emanate. A knowledge of the location of the phase center is important in problems involving interferometers, the feed system of reflector antennas, direction finding, and gain measurements. G. Greving of the Institute for Technical Electronics at Aachen Technical University, in a paper "A New Concept for the Phase-Center Problem" (Paper No. 223A), proposed to determine the phase center of an antenna on the basis of the orthogonality between equiphase surfaces and the energy-flow vector in two-dimensional fields. Calculations were made for a 4-wavelength dipole and for a two-armed logarithmic, conical, broadband antenna. For the dipole a phase center does not exist up to a distance of 10λ; even for very large distances ($> 100\lambda$) a unique phase center could not be found. The calculated result for the logarithmic conical antenna checked well with published experimental data.

An important tool for calculating the transient electromagnetic behavior of a scattering object is the so-called singularity-expansion method (SEM). In this method the transient response is expressed in terms of the natural modes of the scattering object which correspond to the singularities in the complex frequency plane. A.G. Tijhuis and H. Blok of Delft University of Technology used the SEM approach to find the reflected and transmitted fields due to a rectangular pulse incident normally on a lossy homogeneous slab and on a lossless inhomogeneous slab (Paper No. 221B). For the homogeneous slab, the SEM poles were determined by Muller's iterative method. For the inhomogeneous slab the natural frequencies were found with the aid of Runge-Kutta integration method.

It is known that the radiation characteristics of a loop antenna placed near a lossy ground are much less affected by the electrical properties of the ground than those of a dipole antenna. In a paper (No. 313A) "Impedance Characteristics of Small Loop Antennas above a Conducting Half Space," W. Papousek and B. Schnizer of Graz Technical University, Austria, calculated the input impedance of small loop antennas placed vertically, horizontally, or obliquely with respect to a homogeneous lossy half-space. The loop antennas were approximated by magnetic dipoles and the Sommerfeld integrals for the reaction field were evaluated by numerical methods. It was found that for frequencies less than 1 MHZ, the change in loop input resistance was larger over dry ground than over sea water. At higher frequencies, the effects were reversed; the crossing point depended on antenna orientation and its height above the ground.

In a paper (No. 314A) entitled "A Hybrid MM-GTD Technique for the Treatment of Wire Antennas Mounted on a Curved Surface," L.W. Henderson of the Ohio State University and G.A. Thiele of the University of Dayton used the moment method to analyze the wire antennas and added perturbation terms due to interaction with the nearby curved surface. The perturbation terms included the coupling between the test and expansion modes due to rays reflected and diffracted from the curved surface. Numerical results were obtained for the mutual impedance of two parallel dipoles in the presence of an infinite circular cylinder and for the input resistance of a quarter-wave dipole mounted on an infinite circular cylinder.

B.D. Popovic and A.R. Djordjevic of the University of Belgrade described a novel comblike trapezoidal broadband antenna in their paper (No. 321A) "Experimental and Theoretical Analysis of Anisotropic Trapezoidal Antennas." The base of the comb is mounted close to the ground plane and is fed at one end by a coaxial line (Fig. 1). Such an antenna has uniquely defined polarization and very good aerodynamic properties. An approximate theoretical model was adopted. Experimental results showed that a usable frequency range of two octaves was obtainable for a VSWR less than 2.0. The radiation pattern varies gradually with the operating frequency. The directivity of the antenna is about 4.

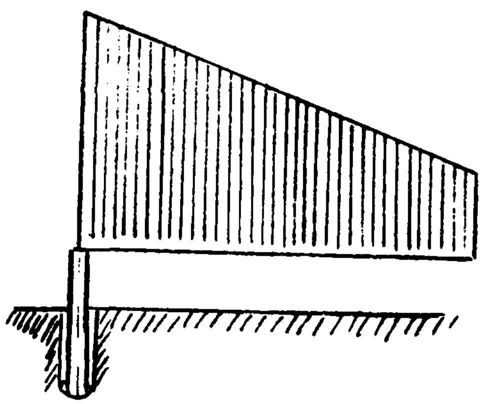

Figure 1

Another novel wide-band antenna was presented by Kazuhito Matsumura from the Utsunomiya University in Japan. Paper No. 324A, Alternate-Leaves-Type Self-Complementary Plane Antenna," was written in collaboration with Norio Nasu. The antenna shape reminds one of logarithmic spiral antennas and is shown in figure 2. The lowest frequency is determined by the length of the outermost limb. Experimental results give a bandwidth of 3 octaves (145-1050 MHz).

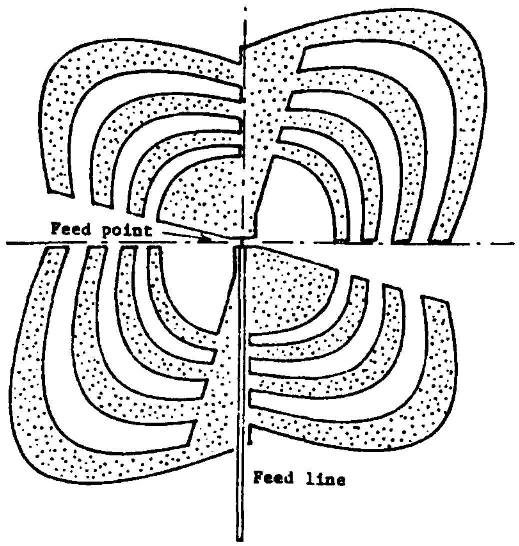

Figure 2

Nondestructive and noninvasive measurements of the dielectric properties of biomedical material were described by a team from the Ecole Polytechnique Fédérale in Lausanne, Switzerland. J.C.E. Besson read the paper (No. 124A), "Reflection of an Open-ended Coaxial Line: Application to Nondestructive Measurement of Materials," which was written in cooperation with J.R. Mosig and F.E. Gardiol. They used the fringe field of an open-circuited, flanged coaxial line placed against the sample. Considerable computational complexity was found but asymptotic derivations allowed the calculations of the reflection coefficients from materials with high permitivity. First measurements with a coaxial cavity showed good agreement with open-circuit methods.

P.J.B. Clarricoats from the Queen Mary College, London, presented a paper (No. 131A) co-authored by C.G. Parini and M.S.A.S. Rizk, "Prediction and Performance of Radome covered Reflector Antennas." They calculated the reflection coefficient of a paraboloidal radome and its effects on the radiation patterns of a paraboloidal reflector antenna. He reported finding a method of reducing the reflection losses by about 5dB by using a hemispherical iris-loaded sandwich at the center of the radome.

High-precision, large reflector antennas were discussed by J.W.M. Baars of the Max-Planck Institut für Radioastronomie (MPIfR), Bonn, FRG, in his paper (No. 143A) "Design of Large Millimeter Radio Telescopes." Baas examined the limitations in achievable structural tolerances and deformations, thermal or gravity and its correction or adaptive methods of compensation. He described an MPIfR 30 m diameter Cassagrainian re-

flector. It used 420 alumina honeycomb surface panels, achieving an acuracy of 40-50 µm. Peak deformation was 6 mm, but the total surface errors rms were only 90 µm. It is usable to 300 GHz when its beam-width is 8 arcseconds. Production cost was $13 million.

Polarization control had been studied by I. Kotlarenko and J. Shipira from RAFAEL and from the Haifa Technion in Israel. Kotlarenko presented a paper (No. 245A) "Broad-band, Wide-angle Electromagnetic Wave Polarizers." He considered two types: firstly, a multilayered meanderline that is oriented at 45° to the incoming linear polarization which it transforms to circular polarization, and secondly, a multilayered parallel slant-strip which gradually changes orientation from layer to layer and thereby rotates the polarization. Performance is analyzed using a transmission-line model and special attention is paid to limitations due to changes in angle of incidence, as would occur with electronic scanned systems. It was found that both polarizers could be made to be quite broad-band but that the polarization twisting slant-lines had potential for wide variations in angle of incidence. Examples given included a three layer slant-strip polarizer giving a 2.5-1 frequency band and and allowing incident angles to vary up to 45°, and a four-layer meanderline giving almost octave-band width.

The conference was unquestionably a success, and interesting work was reported. Once again, though, we would plead for more conscientious preparation and critical scrutiny of viewgraphs so as to avoid the alas, much-too-common, hand-scribbled, indigestible figures, that are undoubtedly crammed with information, but are not understandable.